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(54) **Forged joints.**

(57) A method of forming a joint between two bars, (10 and 11) uses a tubular stub (12) of circular or square cross-section to interconnect the bars. The bars (10 and 11) are positioned with their axes at the required relative disposition, and with the stub (12) therebetween, the stub axis intersecting the two bar axes (1). The bars are then forced together (2), until the stub is deformed sufficiently to surround partially the two bars (3). The stub (12) may be heated initially, and the completed joint subjected to forced cooling, to take advantage of the thermal contraction of the stub to enhance the strength of the connection.

The method may be modified (4 7) to effect a T-joint between a bar and a tubular member, in which case no separate stub need be used. Instead, two opposed regions and, of the end portion of the tubular member are deformed inwardly so as to form a groove across the end of the member, with 'ears' and upstanding on each side of the groove. The bar is then pressed into the groove, until the ears and become formed partially around the bar (6), so gripping the bar. Again, the tubular member may be heated so that the deformed member thermally contracts on to the bar.

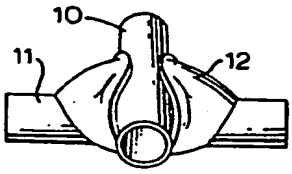

FIG.3

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FORGED JOINTS

This invention relates to joints between two members, and particularly to methods of effecting such joints which methods do not require the use of welding or screw-threaded fasteners. The invention expressly relates to methods of forming a joint between two bars, or between a bar and a tubular member, so that the axes thereof extend at an angle to one another.

There are many techniques which may be employed when two metallic bar or rod-like members are to be joined together with their axes lying at an angle to one another. A relatively cheap and mechanically most effective technique is to weld together the two members, but often a manually-welded joint is not particularly aesthetically pleasing. Moreover, such a weld requires considerable skill, in order to ensure that the finished joint is mechanically sound. By contrast, a connection using screw-threaded fasteners requires less skill but again is not usually pleasing aesthetically and of course is relatively expensive to implement, in view of the need to drill the members and to provide the screw-threaded fasteners. A clamp device may be used to join together two or more members, and though such a clamp device can be proportioned to give the finished joint an attractive appearance, the cost of such a clamp often is prohibitively high.

It is a general object of this invention to provide methods of forming joints between two members which methods require relatively little skill to perform and yet can give a mechnically sound joint. The methods moreover aim at permitting the production of relatively cheap joints which do not require the use of expensive formed components such as clamps and screw-threaded

fasteners, but which can have an aesthetically-pleasing appearance.

According to one aspect of this invention, there is provided a method of forming a joint between two bars so as to extend with their axes at an angle to one another, which method is characterised by the steps of arranging the two bars at the required angular disposition but with a space therebetween, positioning a tubular plastically deformable stub between the two bars with the axis of the stub substantially intersecting the axes of the two bars, and then pressing the two bars closer together thereby plastically to deform the stub so as to become at least partially formed around both of the two bars.

Most preferably, the method of this invention is performed with the use of a metallic stub which is heated prior to being positioned between the two bars, the stub being allowed to cool after the plastic deformation thereof by the pressing together of the two bars, whereby the stub contracts firmly to grip the two bars.

Performance of the method of this invention shows that a joint can be formed between two bars with the outer surfaces of the bars closely adjacent or touching, which joint is aesthetically most pleasing. The only component required other than the two bars themselves is a simple tubular stub cut to an appropriate length and which preferably is heated to a sufficient temperature, and such a stub is of course relatively cheap. Moreover, performance of the method requires no particular skill, once the proportions of the stub have been determined. In a case where the stub is heated, the joint when completed will be particularly reliable and secure, by virtue of the significant forces generated by the contraction of the stub, upon cooling. The tubular stub may have any suitable cross-sectional

shape, but normally circular or square stock would be employed, and though the overall appearance of the joint will vary slightly depending upon the cross-sectional shape of the stock, especially aesthetically pleasing joints are obtained with square stock.

In the preferred method where the stub is heated, the contraction of the tubular stub upon the cooling thereof enhances the security of the joint. Thus, the deformation of the stub so as at least partially to be formed around the two bars should be completed before the temperature of the stub has dropped significantly - but thereafter, cooling of the stub should proceed as rapidly as possible. If significant quantities of heat are transferred from the stub to the two members such that the two bars become heated and expand, subsequently during the cooling there will be no differential contraction between the stub and bars, and a less secure joint will result. Accordingly, though natural cooling may in some cases be satisfactory, forced cooling of the joint is most desirable, particularly where the two bars do not have a particularly high thermal capacity - for example where the two bars comprise metallic tubular members. The forced cooling may for example comprise immersing the joint in a suitable liquid such as in an oil or water bath, or the joint may be cooled by means of a blast of cold air.

The two bars preferably have cross-sectional diameters which are substantially the same or closely similar, but a satisfactory joint can still be obtained with bars of significantly different diameters. Nevertheless, where the bars are of substantially the same diameter, the tubular stub preferably has a diameter (in the case of a circular cross-sectional shape stub) or an across-the-flats dimension (in the case of a square cross-sectional shape stub) equal to approximately twice the diameter of the bars. The

length of the stub preferably is equal approximately to twice the bar diameter - but these just-mentioned figures are given to illustrate the order of magnitude of the relative dimensions, rather than to place positive limitations thereon.

Where the diameters of the two bars differ significantly, the performance of the method may be enhanced by providing a groove across the end of the stub which engages with the larger diameter bar, such that the larger bar is partially received in that groove. In this way, the stub may be deformed around the larger bar to an extent sufficient firmly and securely to grip that bar, as well as to grip the other smaller bar.

According to another aspect of this invention, there is provided a method of forming a joint between a bar and a plastically deformable tubular member so as to have the axes thereof extending substantially at right-angles, which method is characterised by the steps of deforming inwardly the end portion of the tubular member at two opposed sections thereof, pressing the bar on to the deformed end portion of the tubular member with the bar axis over-lying said two inwardly deformed sections, and continuing the pressing until the end portion of the tubular member is plastically deformed to become at least partially formed around the bar.

Most preferably, the method of this invention is performed with a metallic tubular member at least the end portion of which is heated prior to the bar being pressed thereon, the tubular member being allowed to cool after the plastic deformation thereof, whereby the tubular member end portion contracts firmly to grip the bar.

The second aspect of the invention provides a method for making a T-joint, and as with the first-described aspect of the invention, a particularly

aesthetically pleasing joint can be made, at relatively low cost. In fact, with this second method of this invention, no components other than the bar and tubular member themselves need be provided.

In this joint, the end portion of the tubular member is deformed, for example by moving the free edge of the tubular member in the two opposed regions towards each other, so as to confront each other - that is to say, the free edges in the two said regions are moved both radially inwardly and back along the axis of the tubular member. In effect, the end portion of the tubular member then has a generally arcuate groove extending transversely thereacross, with a pair of diametrically opposed 'ears' upstanding on the two sides of the groove. This deformation of the tubular member may be completed to a greater or lesser extent, depending upon the amount by which the tubular member is required finally to encircle the bar.

When making a joint in accordance with the preferred second aspect of the invention, the step of heating the tubular member and that of deforming the end portion thereof inwardly may be performed in either order; however, where the tubular member has a relatively thick wall, there may be advantages in heating the tubular member before deforming the end portion, so as to obtain the required form with only relatively low forces.

As with the first-described joint, the security of the joint may be enhanced by the differential contraction of the tubular member as it cools, with respect to the bar. It is therefore important that forced cooling be employed if the thermal capacity of the bar is such that the temperature of the bar would be raised significantly as it is pressed into engagement with the hot end portion of the tubular member. Such forced cooling may be performed by means of an oil or

water bath or by means of a blast of cold air.

Excellent results are obtained where both the bar and the tubular member are both of substantially circular cross-sectional shape, though provided the members are appropriately proportioned, satisfactory results can be obtained with other cross-sectional shapes. Where both components are of circular cross-sectional shape, the bar preferably has a diameter which is of the order of one half of the diameter of the tubular member; but where the tubular member is of square cross-sectional shape, the bar should have a diameter which is of the order of one half of the across-the-flats dimension of the tubular member.

Though either joint of this invention could be performed using bars and tubular members of a variety of materials, nevertheless the connection methods particularly lend themselves for use with forgeable metals, such as mild steel, stainless steel, copper alloys, aluminium alloys and titanium. For the case of mild steel, the tubular member or stub which is heated should have its temperature raised sufficiently for that material to reach a red/orange colour; this ensures sufficient plasticity to allow the ready deformation thereof whilst retaining sufficient strength to prevent the collapse thereof, during completion of the joint. Moreover, provided that the joint is subsequently completed quickly, the contraction resulting from the cooling of the tubular member or stub from that temperature will be sufficient most securely to hold the or each bar.

This invention extends to joints between two bars, or between a bar and a tubular member, whenever produced by a method of this invention as described above.

By way of example only, the production of two joints in accordance with the two aspects of this invention will now be described in detail, reference being made to the accompanying drawings, in which:-

Figure 1 shows a first stage in forming a joint between two bars in accordance with a first method of this invention;

Figure 2 shows a second stage in forming the joint;

Figure 3 is a view of the completed joint;

Figure 4 shows a first stage in forming a joint between a tubular member and a bar in accordance with a second aspect of this invention;

Figure 5 shows a second stage in the second method;

Figure 6 is a view of the completed T-joint; and

Figure 7 is a side view of the completed joint of Figure 6.

Referring initially to Figures 1 to 3, there is shown a method for joining together two bars 10 and 11 such that the axes of the two bars extend at right angles. Each bar is in the form of a mild steel tube of circular cross-sectional shape and with an external diameter d. Initially, the two bars are disposed to overlie one another with their axes at right angles, the closest spacing of the two bars 10 and 11 being arranged to be approximately D, D being equal aproximately to 2·d.

The joint is effected by using a mild steel tubular stub 12 of square cross-sectional shape and with an across-the-flats dimension of approximately D. The stub 12 is cut from a piece of stock so as to have a length D and is then heated to a red-orange colour - that is, to a temperature roughly within the range of from 900° to 1100°C. The thus-heated stub 12 is then positioned between the two bars 10 and 11, as shown in

Figure 1, in which position the axis of the stub 12 substantially intersects the axis of the two bars 10 and 11, and each pair of opposed corners overlie a bar.

Immediately after the hot stub 12 has been positioned between the two bars 10 and 11, pressure is applied to the two bars so as to move them towards each other. As the bars move together, the stub 12 is deformed, initially as shown in Figure 2 and the stub 12 eventually takes up the the form shown in Figure 3, at which stage the two bars 10 and 11 are in contact with each other. As illustrated in Figure 3, the stub 12 has been deformed to such an extent that it partially encircles each bar 10 and 11, and the two bars can be separated only if the stub 12 is deformed again.

Immediately after the two bars have been moved together so as to touch, as illustrated in Figure 3, the stub 12 is cooled, for instance by means of an oil bath or a blast of cold air. This forced cooling should be effected so as rapidly to cool the stub, before a sufficient quantity of heat has been transferred to the bars 10 and 11 to cause sigificant expansion thereof. By cooling the stub quickly in this way, the deformed stub contracts and thus tightly grips the two bars 10 and 11. Provided that the cooling is sufficiently rapid to ensure there is differential contraction between the stub 12 and the bars 10 and 11, the completed joint will hold the two bars together in a most secure manner and in the illustrated relative disposition. Moreover, the shape of the stub in its deformed condition lends an aesthetically-pleasing appearance to the completed joint.

As mentioned in the foregoing, it is important that the deformation of the stub 12 is completed before sufficient heat has been transferred to the bars 10 and 11, to cause significant expansion thereof, for otherwise little differential contraction would take

place on cooling the joint, leading to a less secure joint. However, the temperature to which the stub is heated should be sufficiently high to ensure its ready deformation, but should not be so high that the stub has virtually no strength, for then the stub may collapse when the two bars are moved together.

Turning now to Figures 4 to 7, there are shown the successive steps of forming a T-joint, also in accordance with this invention. In this joint, the connection is made between a tubular member 15 and a bar 16, both the member 15 and bar 16 being of circular hollow cross-sectional shape and made of a mild steel material. Typically, the bar 16 has a diameter d equal to one half of the diameter D of the member 15.

The first step in forming the joint is the heating of the end portion of the member 15 to a temperature sufficient to give the member 15 a red-orange colour. Then, the end portion is deformed so as to shape the end portion substantially as illustrated in Figure 4. This is achieved by moving two diametrically opposed regions 17 and 18 of the free edge of the member 15 both radially inwardly towards each other and axially back along the length of the member 15. Such deformation is continued until said two regions 17 and 18 are in contact - or almost in contact - with each other, and the final effect is the provision of a groove 19 extending diametrically across the end portion, with two 'ears' 20 and 21 upstanding one to each side of that groove 19.

Immediately, and before the temperature of the end portion has fallen too much, the bar 16 is positioned across the groove 19 such that the axis of the bar 16 is at right-angles to the axis of the tubular member 15. Pressure is then applied to the bar 16, so as to move the bar along the axis of the tubular member 15, thus deforming the end portion of the tubular member. The

movement of the bar 16 is continued until the ears 20 and 21 have become formed partially around the bar 16, as the bar moves deeper into engagement with the tubular member. As illustrated in Figures 6 and 7, the ears 20 and 21 move to such an extent that they partially encircle the bar 16, so as to resist the withdrawal of the bar.

As soon as the tubular member deformation has reached the stage illustrated in Figures 6 and 7, the tubular member 15 is cooled rapidly, for instance by means of an oil bath or a blast of cold air. This cooling should be effected before sufficient heat has been transferred to the bar 16 to cause significant expansion thereof, such that differential contraction may take place: this cooling thus causes the end portion of the tubular member 15 securely to grip the bar 16, when the joint is cold.

In performing the just-described method, the temperature to which the end portion of the tubular member 15 is heated should be sufficiently high so as to allow the ready deformation thereof, but not so high that the end portion collapses. As mentioned, a red-orange colour is suitable, for the case of a mild steel tubular member, and if necessary a secondary heating step may be employed following the initial forming of the tubular member.

As with the first-described joint, the T-joint described with reference to Figures 4 to 7 is aesthetically-pleasing, whilst being relatively simple and quick to perform. Moreover, no special skill is necessary in the forming of either above-described joint and, because no machined parts such as bolts or clamps are required, the joints are relatively cheap to effect.

CLAIMS

1. A method of forming a joint between two bars so as to extend with their axes at an angle to one another, which method is characterised by the steps of arranging the two bars (10, 11) at the required angular disposition but with a space therebetween, positioning a tubular plastically deformable stub (12) between the two bars with the axis of the stub substantially intersecting the axes of the two bars (Figure 1) and then pressing the two bars (10, 11) closer together (Figure 2) thereby plastically to deform the stub (12) so as to become at least partially formed around both of the two bars (Figure 3). 2. A method according to claim 1, and in which a metallic stub (12) is employed, the method being characterised in that the stub is heated prior to being positioned between the two bars (10, 11), and the stub is allowed to cool after the plastic deformation thereof, whereby the stub (12) contracts firmly to grip the two bars (10, 11).

3. A method according to claim 2, further characterised in that the deformation of the stub (12) so as at least partially to be formed around the two bars (10, 11) is completed before the temperature of the stub has dropped significantly from its initial temperature, and thereafter the completed joint is subjected to forced cooling.

4. A method according to any of the preceding claims and in which the two bars (10, 11) are of circular cross-sectional shape of similar diameters, characterised in that the tubular stub (12) used has a circular or a square cross-sectional shape with a diameter or an across-the-flats dimension, respectively, substantially equal to twice the diameter of the two bars.

5. A method according to claim 4, characterised in that the length of the stub (12) is substantially equal to twice the diameter of the bars (10, 11).

6. A method according to any of claims 1 to 3, and in which the diameters of the two bars differ significantly, characterised in that a groove is formed across the end of the stub which is to be engaged with the larger diameter bar, such that on positioning the stub between the bars, the larger bar is partially received in the groove.

7. A method of forming a joint between a bar and a plastically deformable tubular member so as to have the axes thereof extending substantially at right-angles, which method is characterised by the steps of deforming inwardly the end portion of the tubular member (15) at two opposed sections, (17, 18) thereof (Figure 4), pressing the bar (16) on to the deformed end portion (19) of the tubular member (15) with the bar axis over-lying said two inwardly deformed sections (17, 18) (Figure 5), and continuing the pressing (Figure 6, 7) until the end portion of the tubular member (15) is plastically deformed to become at least partially formed around the bar.

8. A method according to claim 7, in which a metallic plastically deformable tubular member (15) is used, the method being characterised in that least the end portion of the tubular member is heated prior to the bar being pressed thereon, and in that the completed joint is subjected to forced cooling.

9. A method according to claim 7 or claim 8, characterised in that the end portion of the tubular member (15) is deformed by moving the free edge of the end portion at two opposed regions (17, 18) both radially inwardly of the member and back along the axis of the member, thereby to generate a generally arcuate groove (19) extending transversely thereacross.

10. A method according to claim 8, characterised in that the end portion of the tubular member is heated prior to the deformation of the end portion inwardly at two opposed sections (17, 18).

11. A method according to any of claims 7 to 10, further characterised in that the bar is of substantially circular cross-sectional shape and the tubular member is of substantially circular or square cross-sectional shape with the diameter of the bar being substantially one half of the diameter or of the across-the flats dimension respectively, of the tubular member.

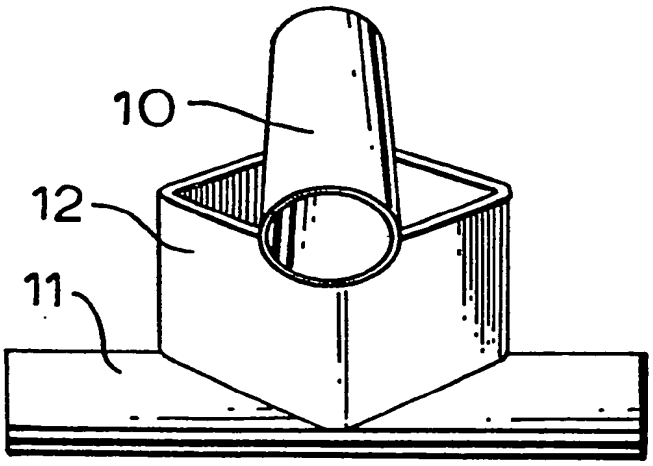

FIG. 1

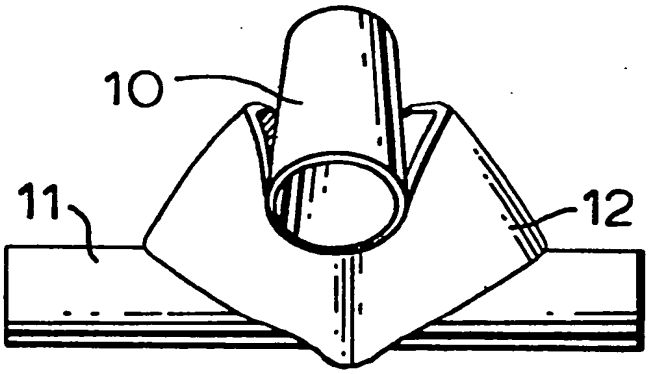

FIG. 2

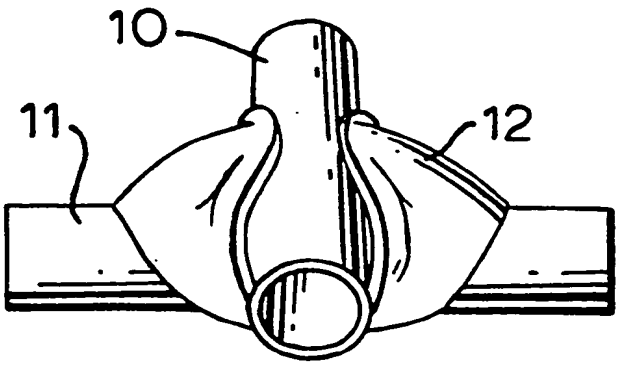

FIG. 3

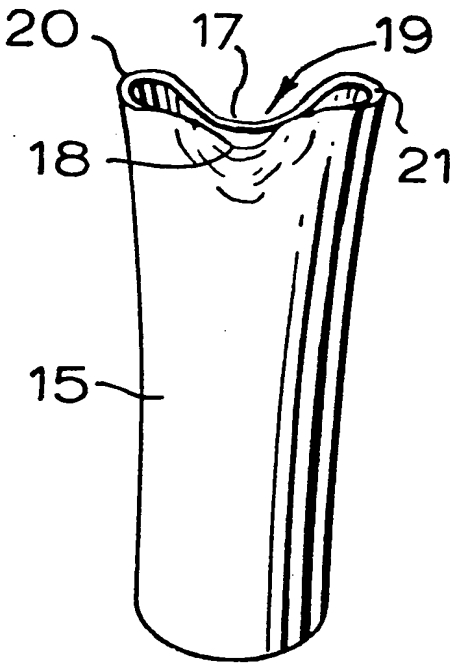

FIG. 4

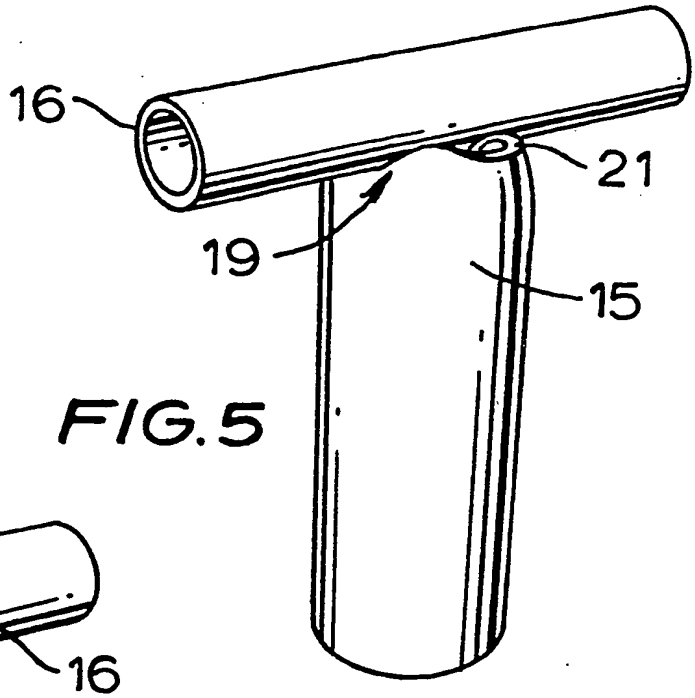

FIG. 5

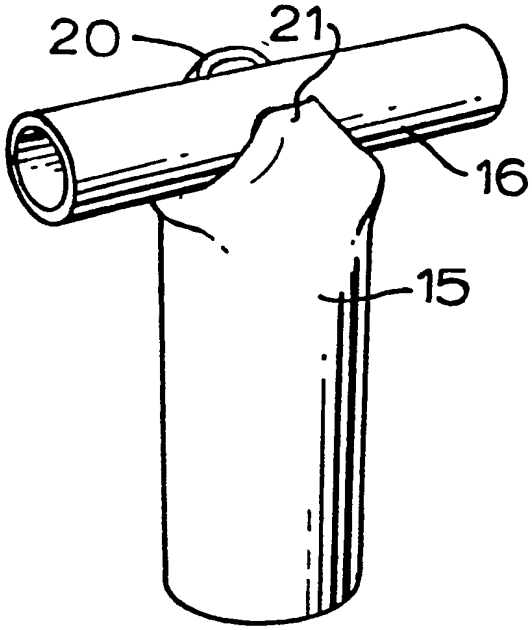

FIG. 6

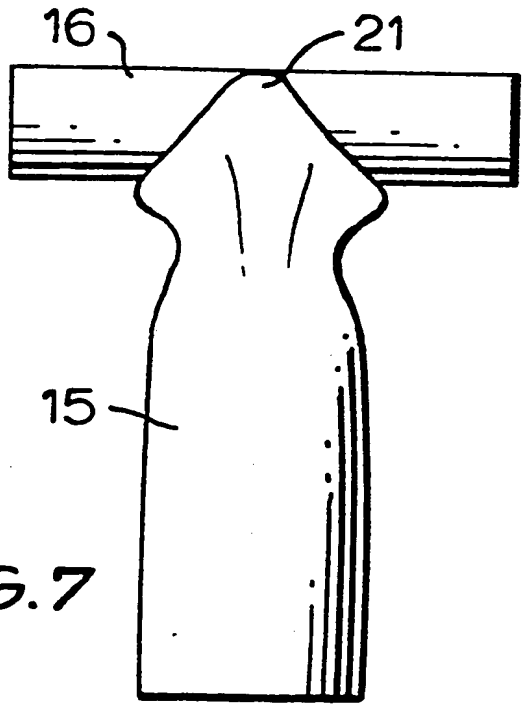

FIG. 7

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EUROPEAN SEARCH REPORT

0095336
Application number

EP 83 30 2882

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y	DD-U- 12 230 (SCHLEIF) * Figures 1-3 *	1,4	F 16 B 4/00
Y	FR-A-2 175 278 (HUIN) * Figure 1 *	1,4	
Y	FR-A-2 328 124 (CASSET) * Figure 1 *	1,4	
Y	DK-C- 94 757 (ANTIFERENCE) * Figure 4 *	1,4	
Y	GB-A-1 365 743 (HURET et al.) * Figure 2 *	1,4	
Y	US-A-3 682 504 (BRIMBERG) * Figure 1 *	1,4	TECHNICAL FIELDS SEARCHED (Int. Cl. ³) F 16 B 4/00 F 16 B 7/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	01-08-1983	ZAPP E

CATEGORY OF CITED DOCUMENTS

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